भारतीय मानक
Indian Standard

IS 4831 : 2019

प्रशीतन के लिए इकाईयों एवं चिन्हों की सिफारिश

(पहला पुनरीक्षण)

Recommendation on Units and Symbols for Refrigeration

(First Revision)

ICS 01.060; 27.200

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
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January 2019 **Price Group 7**

Refrigeration and Air Conditioning Sectional Committee, MED 03

FOREWORD

This Indian Standard (First revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Refrigeration and Air Conditioning Sectional Committee had been approved by the Mechanical Engineering Division Council.

With a view to unifying the practice followed globally in regard to the symbols and units followed in refrigeration and air-conditioning trade, need has been felt to lay down recommendations on the principal quantities primarily used in the field of refrigeration and on their symbols and units of measurement.

This standard was first published in 1968. This revision has been contemplated with a view to align with the International practices and also to include all the units and symbols used globally in the area of refrigeration.

For convenience, certain fundamental quantities and their derivatives have been included which have already been dealt with in IS/ISO 80000-4 : 2006 'Quantities and units — Part 4: Mechanics' and IS/ISO 80000-5 : 2007 'Quantities and units — Part 5: Thermodynamics'.

The column for remarks in Table 1 provide definitions or explanations of quantities which are not given in IS/ISO 80000-4 : 2006 and IS/ISO 80000-5 : 2007.

The various quantities have been grouped in a logical order so as to facilitate their location by the users of this standard. In certain cases when the same symbol may have more than one meaning, a second symbol has been proposed. The units are separated into two sections, namely, units of the International System (SI) and units of other systems which are at present very widely used. In order to obtain the SI units which are equivalent to other units, conversion factors have been included in this standard.

India has changed to metric system of weights and measures. Although this standard gives both metric and FPS units, metric units shall be used (FPS units given in this standard are for information only).

The basic and the derived units of the SI system with their definitions are given in IS/ISO 80000-2 : 2009 'Quantities and units : Part 2 Mathematical signs and symbols to be used in the natural sciences and technology'.

This standard is based on ISO 80000-1: 2009 'Quantities and units : Part 1 General', on the guidelines of SI units issued by the International Organization for Standardization.

The composition of the Committee responsible for the formulation of this standard is given in Annex A.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

RECOMMENDATION ON UNITS AND SYMBOLS FOR REFRIGERATION

(First Revision)

1 SCOPE

This standard prescribes the units and symbols used in refrigeration.

2 QUANTITIES, SYMBOLS, DIMENSIONS AND UNITS

2.1 The quantities, symbols, dimensions and units are given in Table 1.

2.2 The conversion factors given in Table 1 shall be used as multipliers for 'other units' to obtain SI units Example: 1 ft = 0.304 8 m exactly.

Table 1 Quantities, Symbols, Dimension and Units

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
1.	Length	l	metre	m	foot	ft	0.304 8 exactly	-
					inch	in	0.025 4 exactly	-
2.	Area, Surface	*A*	square metre	m^2	square foot	ft^2	0.092 903 0	-
					square inch	in^2	$6.451\ 6 \times 10^{-4}$ exactly	-
3.	Volume	*V*	cubic metre	m^3	cubic foot	ft^3	$28.316\ 8 \times 10^{-3}$	-
					cubic inch	in^3	$16.387\ 1 \times 10^{-6}$	-
4.	Mass	m	kilogram	kg	pound	lb	0.453 592 37	-
5.	Time	t	second	s	minute	min	60	-
					hour	h	3 600	-
6.	Frequency	f	hertz	Hz	-	-	-	Also called cycles per second
7.	Rotational speed	n	rev/s	-	revolution per minute	min^{-1}	1/60	-
8.	Density (mass density)	ρ	kilogram per cubic metre	kg/m^3	pound per cubic foot	lb/ft^3	16.018 5	-
9.	Specific volume	v	cubic metre per kilogram	m^3/kg	cubic foot per pound	ft^3/lb	0.062 4	-
10.	Mass flow rate	q_m	kilogram per second	kg/s	pound per hour	lb/h	126×10^{-6}	Fluid mass flowing in unit time
11.	Volume flow rate	q_v	cubic metre per second	m^3/s	cubic foot per hour	ft^3/h	$7.865\ 79 \times 10^{-6}$	Fluid volume flowing in unit time

Table 1 — (*Continued*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
12.	Thermodynamic or absolute temperature	T, Θ	kelvin	K	Rankine degree	°R	5/9	If t_c°C, t_F°F, T_KK, andT_R°R are referring to and one and same physical state, the figures t_c , t_F, T_K and T_R are evaluated as t_C =5/9(t_F-32) = T_K-273.15=5/9T_R -273.15
13.	Customary temperature	t, θ	degree Celsius	°C	Fahrenheit degree	°F	t_C=5/9(t_F-32)	t_C = T_K-273.15 t_F = T_R-459.67
14.	Temperature difference	Δt, Δθ ΔT, ΔΘ	kelvin	K	Fahrenheit degree	°F	5/9	The general conference of weights and measures has recommended that the world 'degree' or its abbreviation deg' should be used for temperature intervals or differences. The abbreviations K and °C are still often used.
15.	Coefficient of linear thermal expansion	α_l	per kelvin	K^{-1}	per Fahrenheit degree	$°F^{-1}$	5/9	α_l = 1/l dl/dt
16.	Coefficient of volume expansion	α_v	per kelvin	K^{-1}	per Fahrenheit degree	$°F^{-1}$	9/5	α_v = 1/v$(dv/dt)_p$
17.	Coefficient of thermal pressure increase	β	per kelvin	K^{-1}	per Fahrenheit degree	$°F^{-1}$	9/5	β = 1/p$(dp/dt)_v$
18.	Coefficient of compressibility	χ	square metre per newton	m²/N	square inch per pound force	in^2 /lb	1.450 37×10^{-4}	x_t = 1/v$(dv/dp)_t$

Table 1 — (*Continued*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
19.	Force	F	newton	N	dyne	dyn	10^{-5} exactly	-
					kilogram force	kgf	9.806 65 exactly	-
					pound force	lbf	4.448 22	-
20.	Pressure	p	pascal	Pa	bar	bar	10^{-5} exactly	1 bar = 1 hectopieze (hpz)
					kilogram force per square centimetre	kgf/cm^2	98 066.5 exactly	1 kgf/cm^2 = technical atmosphere (at)
					normal atmosphere	atm	101 325 exactly	-
					pound force per square foot	lbf/ft^2	47.880 3	-
					pound force per square inch	lbf/in^2	6 894.76	-
					millimetre of water	mm H_2O	9.806 65 exactly	-
					millimetre of mercury	mm Hg	133.322	1 mm Hg = 1 torr
					inch of water	in H_2O	249.089	-
					inch of mercury	in Hg	3 386.39	-
21.	Surface tension per metre	γ	newton	N/m	dyne per centimetre	dyn/cm	10^{-3} exactly	-
22.	Dynamic viscosity	μ	newton second per square metre	N.s/ m^2	poise	P	0.1	-
					kilogram force second per square metre	$kgf.s/m^2$	9.806 65 exactly	-
					pound force second per square foot	$lbf.s/ft^2$	47.880 3	-

Table 1 — (*Continued*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
23.	Kinematic viscosity	ν	square metre per second	m^2/s	stokes	St	0.0001	1 St = 1cm^2/s
					square foot per second	ft^2/s	0.092 903 0	-
24.	Work	W	joule	J	kilowatt hour	kWh	3.6x10^6 exactly	-
					erg	erg	10^{-7}exactly	-
					kilogram force metre	kgf.m	9.806 65 exactly	-
					foot pound force	ft.lbf	1.355 82	-
25.	Power	P	watt	W	horse power	hp	745.70	1 hp = 550 ft.lbf/s
					metric horsepower	-	735.499	1 metric horsepower = 75 kgf.m/s
26.	Specific work	w	joule per kilogram	J/kg	foot pound force per pound	ft.lbf/lb	2.989 0	The work done per unit of mass
27.	Heat quantity	Q	joule	J	International kilocalorie	kcal	4 186.8 exactly	1 kWh = 859.845 kcal
					kilocalorie 15°C	kcal	4 185.5	In the refrigeration field the unit 'frigorie', extraction of 1$kcal_{15}$ from the body to be cooled
					British thermal unit	Btu	1 055.06	-
28.	Heat flow rate	Φ	watt	W	International kilocalorie per hour	kcal /h	1.163 exactly -	-
					British thermal unit per hour	Btu/h	0.293 071	-

Table 1 — (*Continued*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
29.	Density of heat flow rate	φ	watt per square metre	W/m²	International kilocalorie per hour square metre	$kcal/(h.m^2)$	1.163 exactly	-
					British thermal unit per hour square foot	$Btu/(h.\ ft^2)$	3.154 59	-
30.	Heat transfer capacity (heat load)	Φ_k	watt	W	International kilocalorie per hour	kcal /h	1.163 exactly	Heat flow rate rejected to the hot body from a refrigerating machine
					kilocalorie at15°C per hour	kcal /h	1.162 6	-
					British thermal unit per hour	Btu/h	0.293 071	-
31.	Refrigerating capacity	Φ_0	watt	W	frigorie per hour	fg/h	1.162 6	1 fg/h = 1 kcal/h
					ton of refrigeration	ton	3 516.85	1 ton of refrigeration = a heat flow rate of 3 023.95 kcal/h or 12 000 Btu/h removed by the refrigerating system from the cold body
32.	Efficiency	η	-	-	-	-	-	-
33.	Indicated efficiency	η_d	-	-	-	-	-	Ratio of the indicated power of a compressor to the ideal power with isothermal compression

Table 1 — (*Continued*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
34.	Mechanical efficiency	η_m	-	-	-	-	-	Ratio of the indicated power of a compressor to the input power
35.	Volumetric efficiency	η_v	-	-	-	-	-	Ratio of the fluid volume drawn in during the suction time at the suction conditioning to the volume displaced in the cylinder or cylinders of compressor
36.	Isentropic efficiency of adiabatic compression	η_i	-	-	-	-	-	Ratio of the power of an isentropic compression (reversible adiabatic) to the actual power supplied to the same fluid mass flow rate from the initial to the final state(enthalpies difference)
37.	Isothermal compression efficiency	η_t	-	-	-	-	-	Ratio of the power with reversible isothermal compression to the actual power supplied to the same fluid mass flow rate from the initial to the final state

Table 1 — (*Continued*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
38.	Coefficient of performance	ε	-	W/W	International kilocalorie per watt hour	kcal/Wh	1.163	Ratio of refrigerating capacity to the absorbed power (for a cycle, a machine, a compressor etc)
					British thermal unit per horse power hour	Btu/hp.h	0.000 393	-
					British thermal unit per watt hour	Btu/Wh	0.293	-
					Ton of refrigeration per horse power	Ton/hp	4.716	-
39.	Refrigeration capacity per unit volume	q_o	joule per cubic metre	J/m^3	frigorie per kilocalorie	fg/kcal	-	-
					International kilocalorie per cubic metre	$kcal_{IT}/m^3$	4 186.8 exactly	Ratio of the refrigerating capacity to the volume flow rate in a clearly defined condition
40.	Internal energy	U	joule	J	International kilocalorie	kcal	4 186.8 exactly	E = (H–He) –Te (S–Se)
					British thermal unit	Btu	1 055.06	Also called ‘vaporization enthalpy difference’, ‘fusion enthalpy difference’, ‘Latent heat’ etc. The type of transformation should be indicated in each case

Table 1 — (*Continued*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
41.	Enthalpy	H	joule	J	International kilocalorie	kcal	4 186.8 exactly	E = (H-He) -Te (S-Se)
					British thermal unit	Btu	1 055.06	Also called ‘vaporization enthalpy difference’, ‘fusion enthalpy difference’, ‘Latent heat’ etc. The type of transformation should be indicated in each case
42.	Free energy	F	joule	J	International kilocalorie	kcal	4 186.8 exactly	E = (H-He) -Te (S-Se)
					British thermal unit	Btu	1 055.06	Also called ‘vaporization enthalpy difference’, ‘fusion enthalpy difference’, ‘Latent heat’ etc. The type of transformation should be indicated in each case
43.	Free enthalpy	G	joule	J	International kilocalorie	kcal	4 186.8 exactly	E = (H-He) -Te (S-Se)
					British thermal unit	Btu	1 055.06	Also called ‘vaporization enthalpy difference’, ‘fusion enthalpy difference’, ‘Latent heat’ etc. The type of transformation should be indicated in each case

Table 1 — (*Continued*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
44.	Energy	E	joule	J	International kilocalorie	kcal	4 186.8 exactly	E = (H-He) -Te (S-Se)
					British thermal unit	Btu	1 055.06	Also called ‘vaporization enthalpy difference’, ‘fusion enthalpy difference’, ‘Latent heat’ etc. The type of transformation should be indicated in each case
45.	Latent heat	L	joule	J	International kilocalorie	kcal	4 186.8 exactly	E = (H-He) -Te (S-Se)
					British thermal unit	Btu	1 055.06	Also called ‘vaporization enthalpy difference’, ‘fusion enthalpy difference’, ‘Latent heat’ etc. The type of transformation should be indicated in each case
46.	Specific internal energy	u	joule per kilogram	J/kg	International kilocalorie per kilogram	kcal /kg	4 186.8 exactly	e = (h-he)-Te (s-se)
					British thermal unit per pound	Btu/lb	2 326 exactly	
47.	Specific enthalpy	h	joule per kilogram	J/kg	International kilocalorie per kilogram	kcal /kg	4 186.8 exactly	e = (h-he)-Te (s-se)
					British thermal unit per pound	Btu/lb	2 326 exactly	

Table 1 — (*Continued*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
48.	Specific free energy	f	joule per kilogram	J/kg	International kilocalorie per kilogram	kcal /kg	4 186.8 exactly	e = (h-he)-Te (s-se)
					British thermal unit per pound	Btu/lb	2 326 exactly	
49.	Specific free enthalpy	g	joule per kilogram	J/kg	International kilocalorie per kilogram	kcal /kg	4 186.8 exactly	e = (h-he)-Te (s-se)
					British thermal unit per pound	Btu/lb	2 326 exactly	
50.	Specific energy	e	joule per kilogram	J/kg	International kilocalorie per kilogram	kcal /kg	4 186.8 exactly	e = (h-he)-Te (s-se)
					British thermal unit per pound	Btu/lb	2 326 exactly	-
51.	Specific latent heat of transformation	l	joule per kilogram	J/kg	International kilocalorie per kilogram	kcal /kg	4 186.8 exactly	e = (h-he)-Te (s-se)
					British thermal unit per pound	Btu/lb	2 326 exactly	-
52.	Specific humidity	ω	-	-	-	-	-	Ratio of the mass of moisture in humid air to the mass of dry air present in the mixture
53.	Relative humidity	φ	-	-	-	-	-	Ratio of the water vapour partial pressure to the saturation pressure of pure water vapour at the same temperature

Table 1 — (*Continued*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
54.	Saturation ratio	Φ	-	-	-	-	-	Ratio of the actual specific humidity to the Specific humidity of saturated air at the same temperature NOTE- For temperatures less than 0°C the values in general apply to pure water ice. If it is concerning sub-cooled water the symbols are to be qualified by a particular index.
55.	Entropy	S	joule per kelvin	J/K	International kilocalorie per kelvin degree	kcal /K	4 186.8 exactly	-
					British thermal unit per Rankine degree	Btu/°R	1 899 exactly	-
56.	Specific entropy	s	joule per kilogram kelvin	J/(kg.K)	International kilocalorie per kilogram kelvin	kcal /(kg.K)	4 186.8 exactly	
					British thermal unit per pound Rankine degree	Btu/(lb.°R)	4 186.8 exactly	-
57.	Heat capacity	C	joule per kelvin	J/K	International kilocalorie per kelvin	kcal/K	4 186.8	-
					British thermal unit per degree Fahrenheit	Btu/°F	1 899 exactly	-
58.	Specific heat capacity	c	joule per kilogram kelvin	J/ (kg.K)	International kilocalorie per kilogram degree	kcal/(kg.de g)	4 186.8 exactly	-
					British thermal unit per pound degree Fahrenheit	Btu/lb. °F	4 186.8 exactly	-

Table 1 — (*Continued*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
59.	Specific heat capacity at constant pressure	c_p	joule per kilogram kelvin	J/ (kg.K)	International kilocalorie per kilogram degree	kcal/(kg.deg)	4 186.8 exactly	-
					British thermal unit per pound degree Fahrenheit	Btu/lb. °F	4 186.8 exactly	-
60.	Specific heat capacity at constant volume	c_v	joule per kilogram kelvin	J/ (kg.K)	International kilocalorie per kilogram degree	kcal/(kg.deg)	4 186.8 exactly	
					British thermal unit per pound degree Fahrenheit	Btu/lb. °F	4 186.8 exactly	-
61.	Specific heat capacity ratio	γ, x	-	-	-	-	-	γ, x= c_p/c_v
62.	Thermal conductivity	k, λ	watt per metre kelvin	W/(m.K)	International kilocalorie per hour metre degree	kcal/(h.m.deg)	1.163 exactly	$\lambda_e = d/\Sigma(di/ \lambda i)$ where d is the total thickness of a wall, and di and λi the thickness and conductivities of the wall components
					British thermal unit per hour foot degree Fahrenheit	Btu/(h. ft. °F)	1.730 73	-

Table 1 — (*Concluded*)

Sl No. (1)	Quantity (2)	Symbol (3)	Name SI Unit (4)	Symbol SI Unit (5)	Name Other Unit (6)	Symbol Other Unit (7)	Conversion Factor (8)	Definition and Remarks (9)
63.	Equivalent conductivity	k_e, λ_e	watt per metre kelvin	W/(m.K)	International kilocalorie per hour metre degree	kcal/(h.m.deg)	1.163 exactly	$\lambda_e = d/\Sigma(di/\lambda i)$ where d is the total thickness of a wall, and di and λi the thickness and conductivities of the wall components
					British thermal unit per hour foot degree Fahrenheit	Btu/(h. ft. °F)	1.730 73	-
64.	Convection coefficient of heat transfer	h	watt per square metre kelvin	W/(m²K)	International kilocalorie per hour square metre degree	$kcal/(h.m^3.deg)$	1.163 exactly	-
					British thermal unit per hour foot degree Fahrenheit	$Btu/(h.ft^2.°F)$	5.678	-
65.	Overall coefficient of heat transfer	U	watt per square metre kelvin	W/(m²K)	International kilocalorie per hour square metre degree	$kcal/(h.m^3.deg$	1.163 exactly	-
					British thermal unit per hour foot degree Fahrenheit	$Btu/(h.ft^2.°F)$	5.678	-
66.	Thermal diffusivity	α	square metre per second	m²/s	square meter per hour	m^2/h	0.000 278	-
					square foot per hour	ft^2/h	0.000 025 8	-

ANNEX A

(*Foreword*)

COMMITTEE COMPOSITION

Refrigeration and Air Conditioning Sectional Committee, MED 03

Organization	*Representative (s)*
Indian Institute of Technology, Roorkee	PROF (DR) RAVI KUMAR (***Chairman***)
Annapurna Electronics and Services Ltd, Hyderabad	SHRI G. K. PRASAD SHRI J. S. SASTRY (*Alternate*)
Bureau of Energy Efficiency, New Delhi	SHRI SAURABH DIDDI SHRI MANJEET SINGH (*Alternate*)
Blue Star Ltd, Mumbai	SHRI JITENDRA BHAMBURE SHRI SUNIL JAIN (*Alternate*)
Carrier Aircon Ltd, Gurgaon	SHRI BIMAL TANDON SHRI D. BHATTACHARYA (*Alternate*)
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Centre for Science and Environment, New Delhi	SHRI CHANDRA BHUSHAN
Consumer Education and Research Centre, Ahmedabad	MS SWETA MAHAJAN
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Electrical Research and Development Association, Vadodara	SHRI GAUTAM BRAHMBHATT SHRI RAKESH PATEL (*Alternate*)
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LG Electronics India Pvt Ltd, New Delhi	SHRI GAURAV KOCHHAR SHRI S. T. HAQUE FARIDI (*Alternate*)
National Thermal Power Corporation, Noida	SHRI D. K. SURYANARAYAN SHRI S. K. JHA (*Alternate*)
Refrigeration & Airconditioning Mfr Association, New Delhi	SHRI GURMEET SINGH SHRI R. K. MEHTA (*Alternate*)
Samsung India Electronics Pvt Ltd, Noida	SHRI GAURAV CHOUDHARY SHRI KALICHARAN SAHU (*Alternate*)

Organization	*Representative (s)*
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The Chemours India Pvt Ltd, Gurgaon	SHRI VIKAS MEHTA SHRI NISHIT SHAH (*Alternate*)
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Voltas Ltd, Mumbai	SHRI RITESH SINGH SHRI A. D. KUMBHAR (*Alternate*)
Voluntary Organizationn in Interest of Consumer Voice, New Delhi	SHRI H. WADHWA SHRI B. K. MUKHOPADHYAY (*Alternate*)
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In personal capacity (*506/2, Kirti Apartments, Mayur Vihar, Phase -1 Extension, Delhi*)	SHRI P. K. MUKHERJEE
BIS Directorate General	SHRI RAJNEESH KHOSLA Scientist 'E' and Head (MED) [Representing Director General (*Ex-officio*)]

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This Indian Standard has been developed from Doc No.: MED 03 (1389).

Amendments Issued Since Publication

Amendment No.	Date of Issue	Text Affected

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Published by BIS, New Delhi